TECHNICAL REPORT No. 2
MAY 1, 1956

THE WIND SURVEY

FIRESTOP is a one-year operational study designed to explore certain aspects of mass-fire build-up and behavior and to provide the fire services with some new aids to mass-fire prevention and control.

EXECUTIVE COMMITTEE

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AGRICULTURE—FOREST SERVICE—SAN FRANCISCO

Describing procedures and instrumentation developed for a three month intensive study of air movement patterns in a typical mountain canyon. A few typical results are included and a listing of all available data. Recommendations are given for future wind surveys in major drainage areas.

Fire Stop.

"THE WIND SURVEY"

18 p, illus. (   )

Sound information about local patterns of air movement is an important requirement for effective forest fire control. Measurements of the actual wind field in the immediate environment of the fire as well as other local weather factors are especially needed in the mountainous areas of the West. A few widely scattered weather stations cannot give adequate information about local weather factors and their variability.

For many years, fireweather forecasters of the Weather Bureau and many of the wildland fire control agencies in California have recognized the need for better knowledge of local climatic patterns. The first steps to develop procedures that would give the badly needed information were taken in 1954 when three small-scale wind surveys were undertaken. Two of these surveys were of a very general exploratory nature and have been reported elsewhere.[1/] The third survey, reported here, was part of the program of Operation Firestop. The area of study in this survey was instrumented in considerable detail and included measurements of humidity and temperature as well as of air movement.

The primary purpose of these surveys was to add to the information available on the problems of measuring and recording climatic factors in the field and to learn something of the procedures applicable, data required and methods of analysis needed to provide the information required from a climatic survey.

1/ A Report on the Big Creek Wind Survey, Ralph T. Hanna, Weather Bureau Airport Station, San Francisco, 1955. Upper Sacramento River Drainage Wind Survey, Ralph T. Hanna, WBAS, San Francisco, 1955.

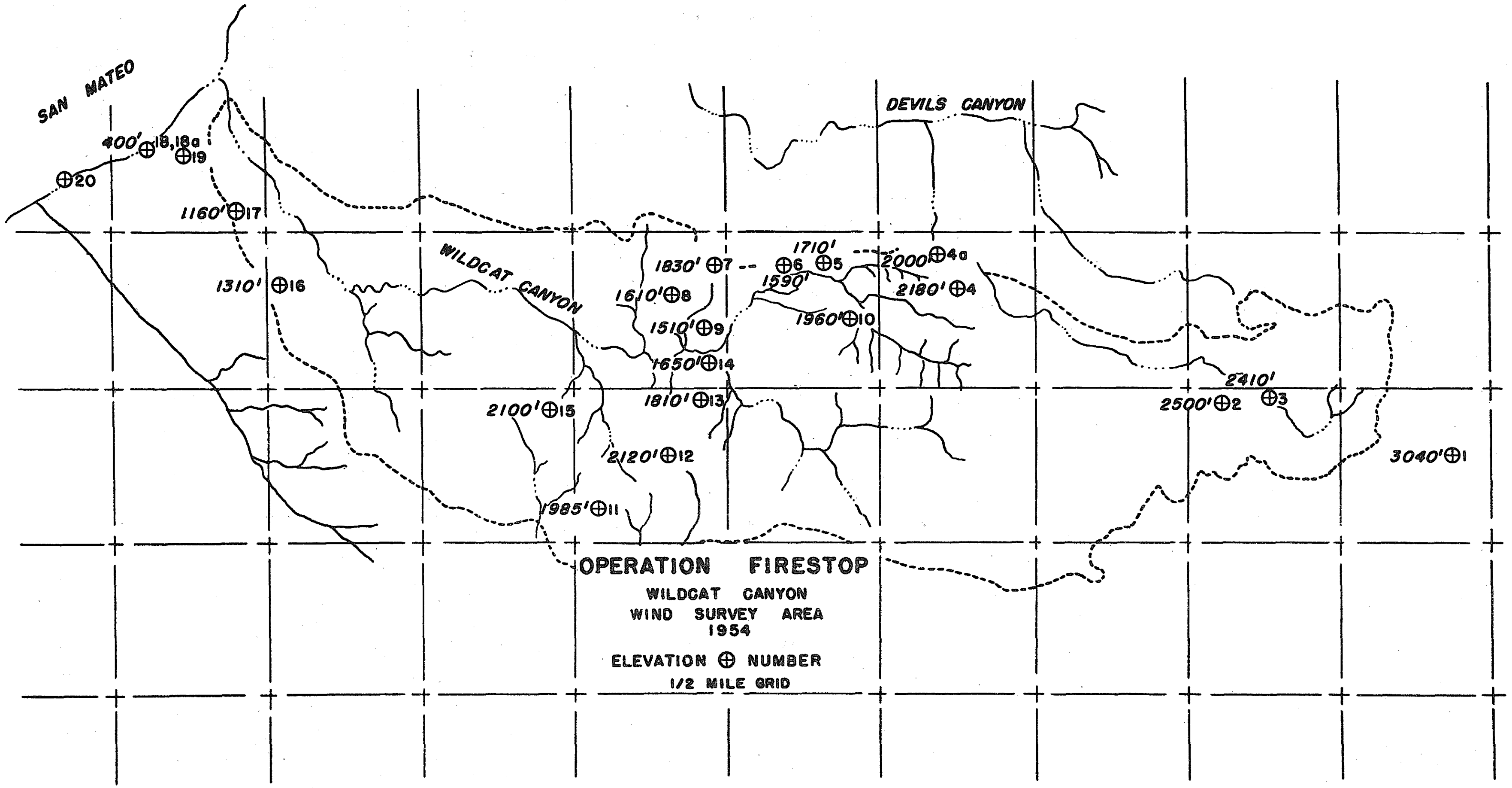

SAN MATEO
400' ⊕18, 18a
⊕19
⊕20
1160' ⊕17
1310' ⊕16
WILDCAT CANYON
DEVILS CANYON
1830' ⊕7
⊕6
1710'
⊕5
1590'
2000' ⊕4a
2180' ⊕4
1610' ⊕8
1510' ⊕9
1960' ⊕10
1650' ⊕14
1810' ⊕13
2100' ⊕15
2120' ⊕12
1985' ⊕11
2410'
2500' ⊕2
⊕3
3040' ⊕1
OPERATION FIRESTOP
WILDCAT CANYON
WIND SURVEY AREA
1954
ELEVATION ⊕ NUMBER
1/2 MILE GRID

Figure 1.

II. OPERATIONAL PROCEDURE

The area chosen for this experimental wind survey was a typical rugged canyon in the Camp Pendleton area on the western slopes of the Coastal Range. The actual canyon used, known as Wildcat Canyon is shown by the outline map in Figure 1 and in the right center of the photograph shown in Figure 2. This canyon is located between the two prominent firebreaks which follow the ridge lines. The mouth of Wildcat Canyon opens into the broad San Mateo Basin, out of view at the bottom of Figure 2. The elevation of the mouth of the canyon is about 400 feet. The canyon extends about 2 miles to the southeast, rising rapidly to an elevation of about 1500 feet. At this point, the canyon divides into two branches with the main (northern) branch making a sharp turn to the northeast and continuing for about 1/2 mile in this direction. At this point, this canyon again makes a sharp turn to the east and continues for about 1/2 mile. Above this point the canyon is not very sharply defined.

Vegetation on the north-facing slopes consists of dense stands of scrub oak (Quercus dumosa), sumac (Rhus laurina), and various species of Ceanothus. The average height of the cover is eight to ten feet. The drier south slopes support only scattered stands of sage (Salvia apiana and Artemisia californica) at the lower elevations and light stands of chamise (Adenostoma fasciculatum) averaging 4 to 5 feet in height in the upper forks of the canyon.

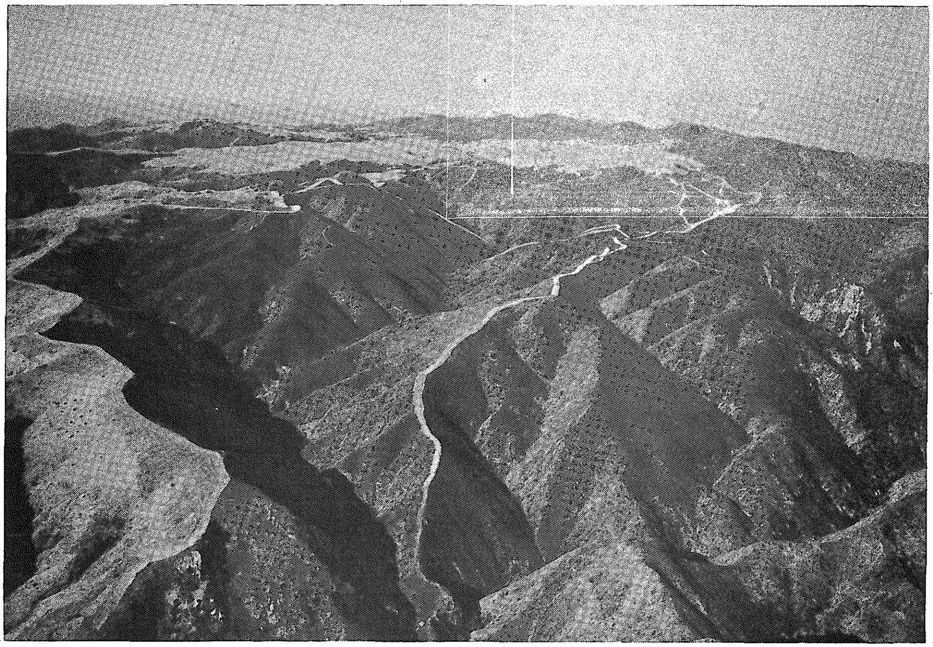


Figure 2. --Wildcat Canyon Wind Survey Area.

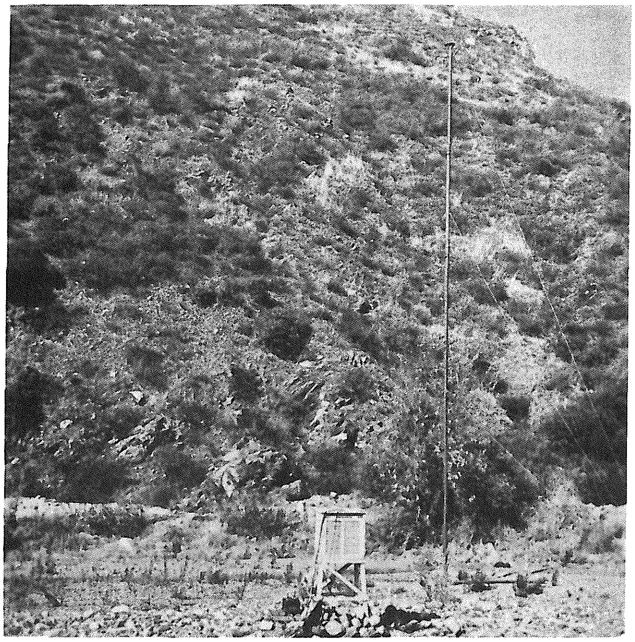


Figure 3. --Tower and Instrument Shelter at Station No. 18.

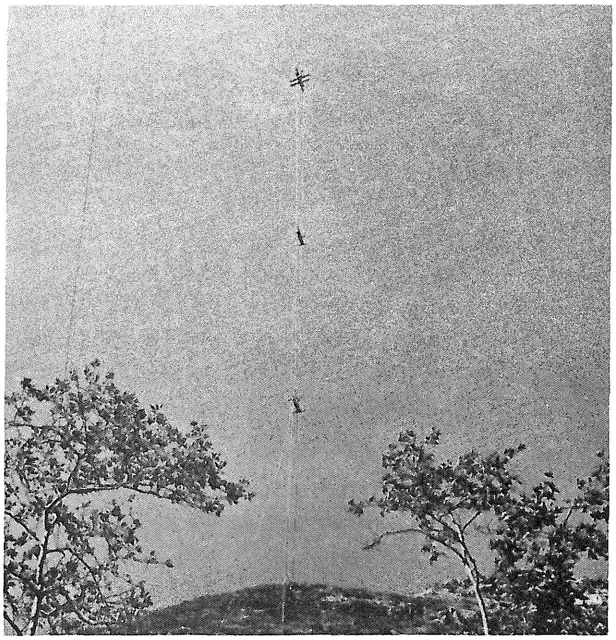


Figure 4. --Instrument assembly on cable at Station No. 19.

Twenty instrument towers were located at strategic sites in this drainage area. These are described in table 1 and marked by the numbered circles in Figure 1. For most stations, the standard height at which air movement was measured was set at the equivalent of 20 feet above open, level ground. Figure 3 shows typical station. Cable installations, which could be moved either vertically or laterally consisted of 5 anemometers and wind vanes suspended approximately 20 feet apart. Figure 4 shows the cable installation at Station 19.

III. INSTRUMENTS

a. Towers

Two types of towers were used at these stations. One type consisted of 10 foot sections of 4 inch plywood tubing and the other of 4-1/2 foot sections of 2 inch aluminum tubing. Anemometers and wind vanes were mounted on the ends of cross bars clamped to the tops of the towers. All of these towers could be easily raised or lowered by two men with the exception of the 50 foot tower at Station 18 which required at least 3 men.

Table 1.--Location of Wind Survey Stations

Station	Remarks	Elevation (Feet)	Location (See Fig. 1)
1	Margarita Peak lookout	3,040	C 10
2	Crest of ridge	2,500	C 9
3	Bottom of ravine adjacent to Station 2	2,410	C 9
4	Crest of ridge	2,180	B 7
4a	Crest of ridge opposite station 4	2,000	B 7
5	Bottom of saddle	1,710	B 6
6	Cable across canyon (5 anemometers)	1,590	B 6
7	North rim of Wildcat Canyon	1,830	B 5
8	North side of Wildcat Canyon	1,610	B 5
9	Bottom of Wildcat Canyon	1,510	B 5
10	Ridge in center of Wildcat Canyon drainage system	1,960	B 6
11	Established for test fire weather measurements. Not included in wind survey network.	1,985	C 5
12	South run of Wildcat Canyon opposite Station 7	2,120	C 5
13	South side of Wildcat Canyon	1,810	C 5
14	Bottom of Wildcat Canyon	1,650	B 5
15	Crest of ridge	2,100	C 4
16	Ridge near mouth of canyon	1,310	B 3
17	Lower end of same ridge as Station 16	1,160	A 2
18	Mouth of Wildcat Canyon	400	A 2
18a	Mouth of Wildcat Canyon (Anemometer height: 50 feet)	400	A 2
19	Cable across canyon (5 anemometers)	400	A 2
20	Basin west of canyon mouth	400	A 1

b. Wind Vanes and Anemometers

The anemometers used were mostly Friez Model 343 with both 1 mile and 1/60th mile contacts. Some of the smaller Friez Airways 3-cup with only the 1/60th mile contact were used at a few sites, especially at the cable installations and at the temporary towers erected for weather evaluation near experimental fires.

SB
421
.F52
no. 2

DED TO
ECORD

The wind vanes were specially designed for this project. The vane armature has eight shorting type electric contacts. When used with an operations recorder wind direction to 16 points can be recorded. At some stations adjacent contacts were connected in pairs which permitted recording of wind direction to only eight points.

Station No. 5 was equipped with a Beckman Whitley Climate Survey Unit. This Unit consists of a sensitive anemometer and wind vane unit which records on 2 Esterline-Angus milliammeter strip chart recorders.

c. Recorders

Two types of recorders were used at all the Stations except Station No. 5. One type was the 20-pen operation recorder, with one pen connected to the anemometer and either 4 or 8 pens connected to the wind vane at each tower. Using this type, more than one set of sensing instruments could be connected to a common recorder. (See Figure 5.) These recorders operated from 6 volt storage batteries.

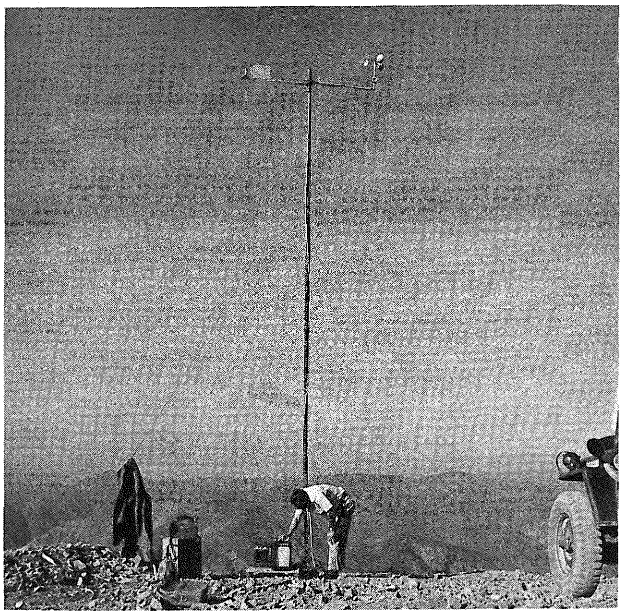


Figure 5. --Typical installation showing recorders, wind vane, and anemometer.

The second type was a modified milliammeter recorder: A multiple resistor was wired into the recorder circuit as shown in Figure 6.

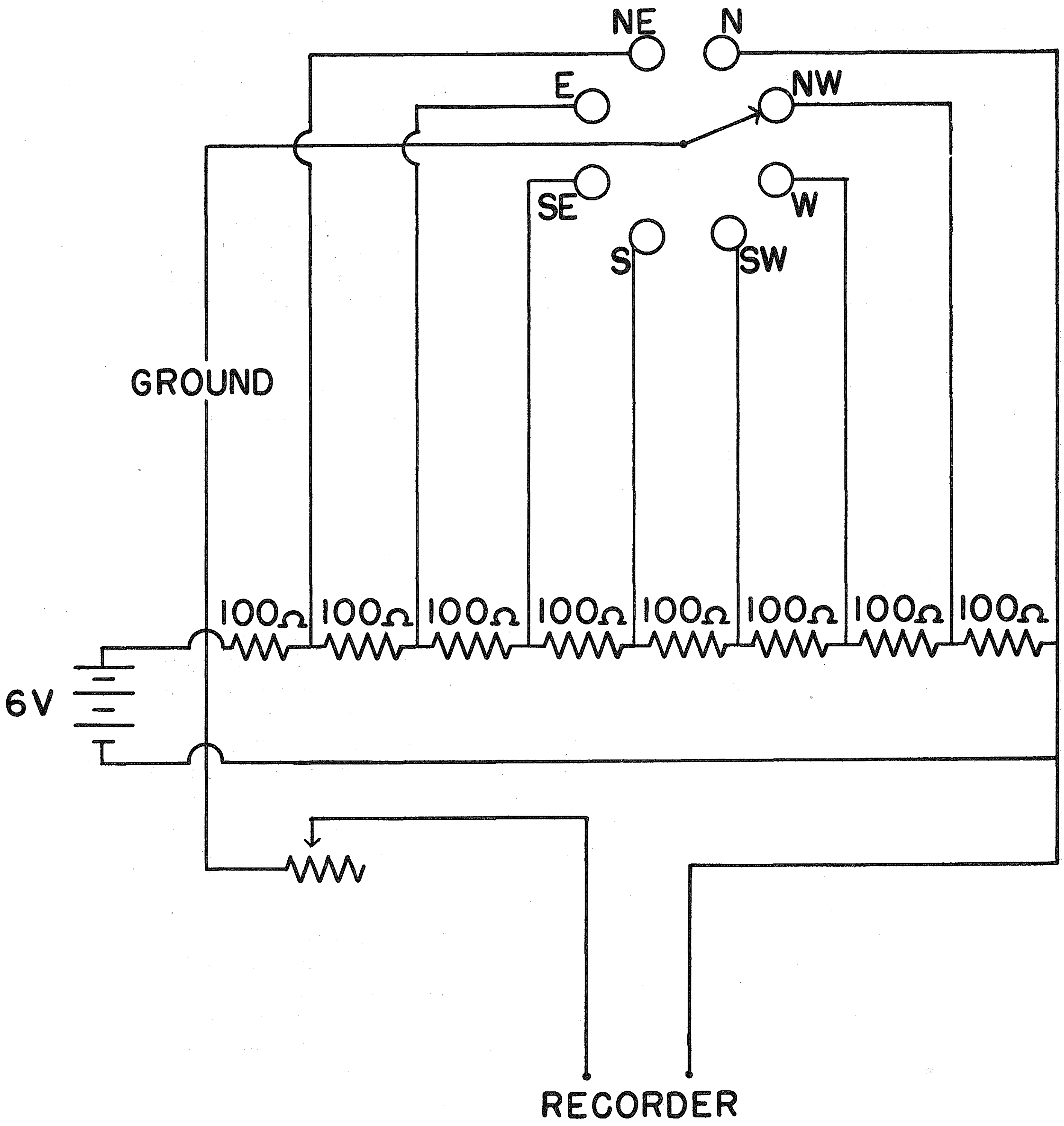


Figure 6. --Wiring Diagram for Resistance type wind vane.

All eight contacts from the wind vane mechanisms and a ground wire were connected into this resistor. With this modified recorder, the eight directions registered in approximately equal steps across the recorder trace. Because of the high resistance, it was possible to operate this circuit with 6 volt dry cells. The register pen on the side of the recorder was connected to the anemometer to record wind speed. A 6 volt storage cell was required for the operation of this anemometer circuit. An illustration of this type recorder is shown in Figure 7.

d. Hygrothermographs and Barographs.

Recording hygrothermographs were installed in Weather Bureau Cotton Region type instrument shelters at Stations Nos. 1, 2, 5, 11, 15, 16, 17 and 18. These gave a continuous record of the temperature and relative humidity at elevations of 400, 1160, 1310, 1710, 1985, 2100, 2500, and 3040 feet.

A standard barograph was installed in the instrument shelter at Station No. 18 and microbarographs were installed at Station No. 1 and at the Firestop Headquarters.

IV. OPERATIONS

a. Daily

Normal operations consisted of having the anemometers set on the 1 mile contact and the recorder chart set to run at 1-1/2 inches per hour. In order to insure reasonable operation of the equipment, it was necessary to have the stations inspected once a day. This inspection included such items as: testing the charge in the storage battery; winding the recorder clock and adjusting the speed of the clock if necessary; checking the recorder paper supply and feed; checking the operation of the pens and the ink supply; checking the correctness of the wind directions; checking the operation of the hygrothermograph pens and ink supply; winding the hygrothermograph clock and regulating the clock if necessary; comparing the hygrothermograph readings with wet and dry bulb temperature readings. When the recorder paper or hygrothermograph sheet had to be changed, beginning and ending times were marked on the charts. A daily inspection summary sheet was kept on all these items. Whenever possible, adjustments and necessary repairs were made in the field. By such inspection, the instruments were not left inoperative for any long period of time. This daily inspection and maintenance required the full time attention of one man.

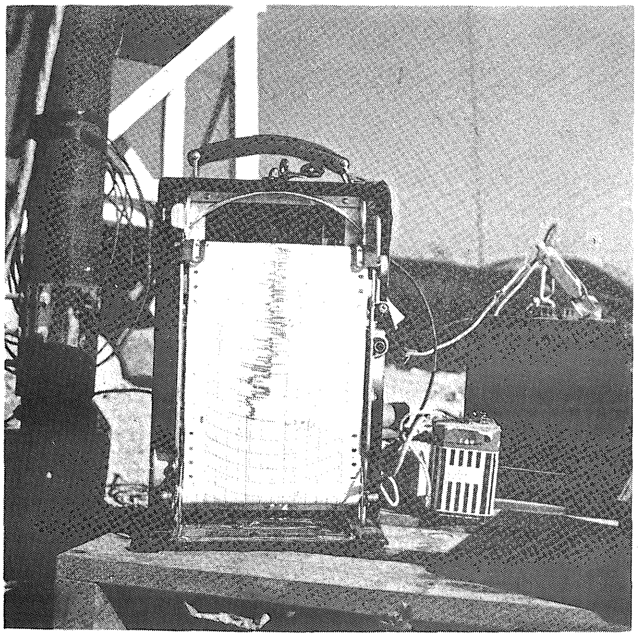


Figure 7. --Esterline Angus milliammeter recorder used with resistance wind vane circuit. (Sample record shown in Figure 10.)

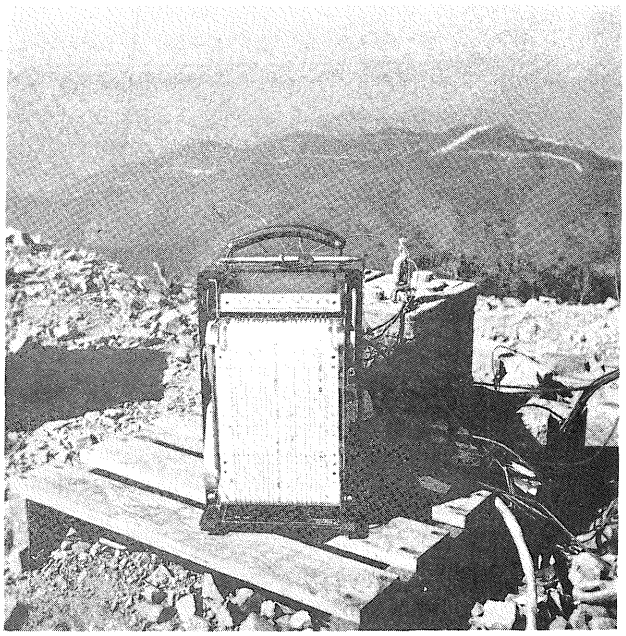


Figure 8. --20-pen operation recorder. 1-pen is connected to the anemometer and either 4 or 8-pens connected to wind vane at each tower. (Sample record shown in Figure 9.)

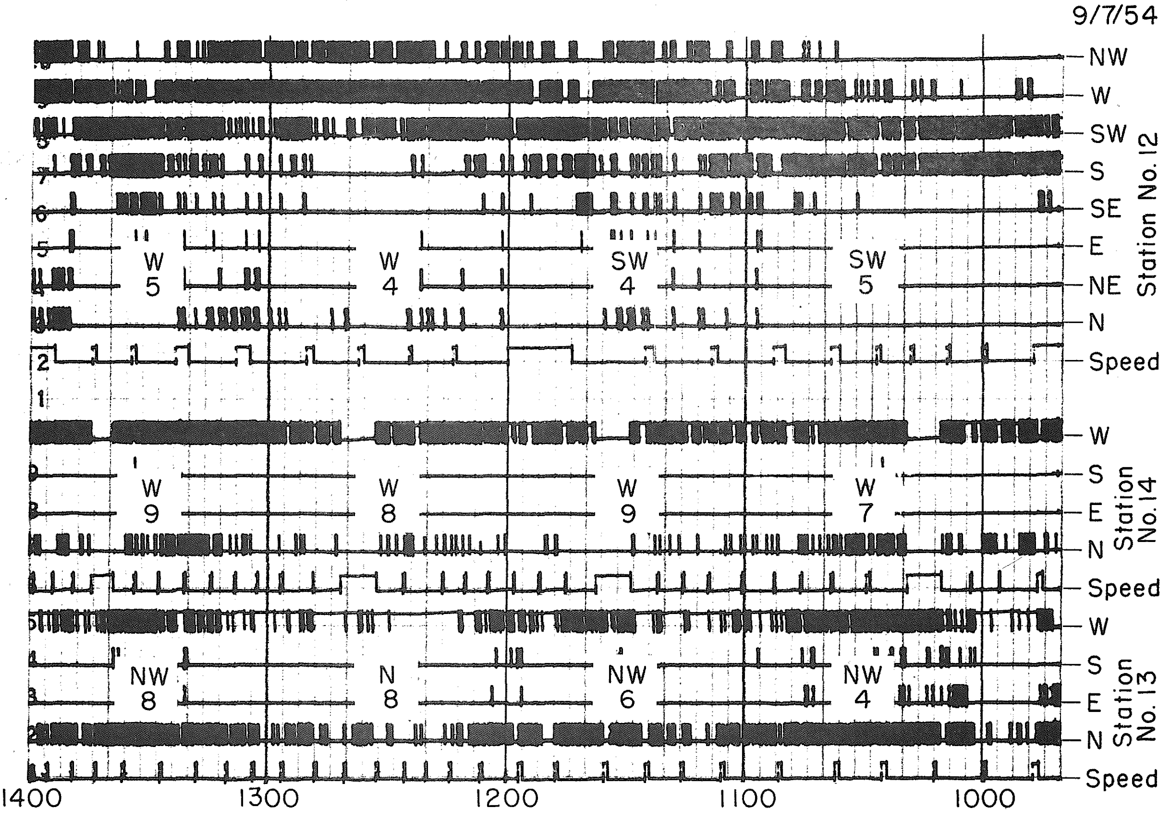
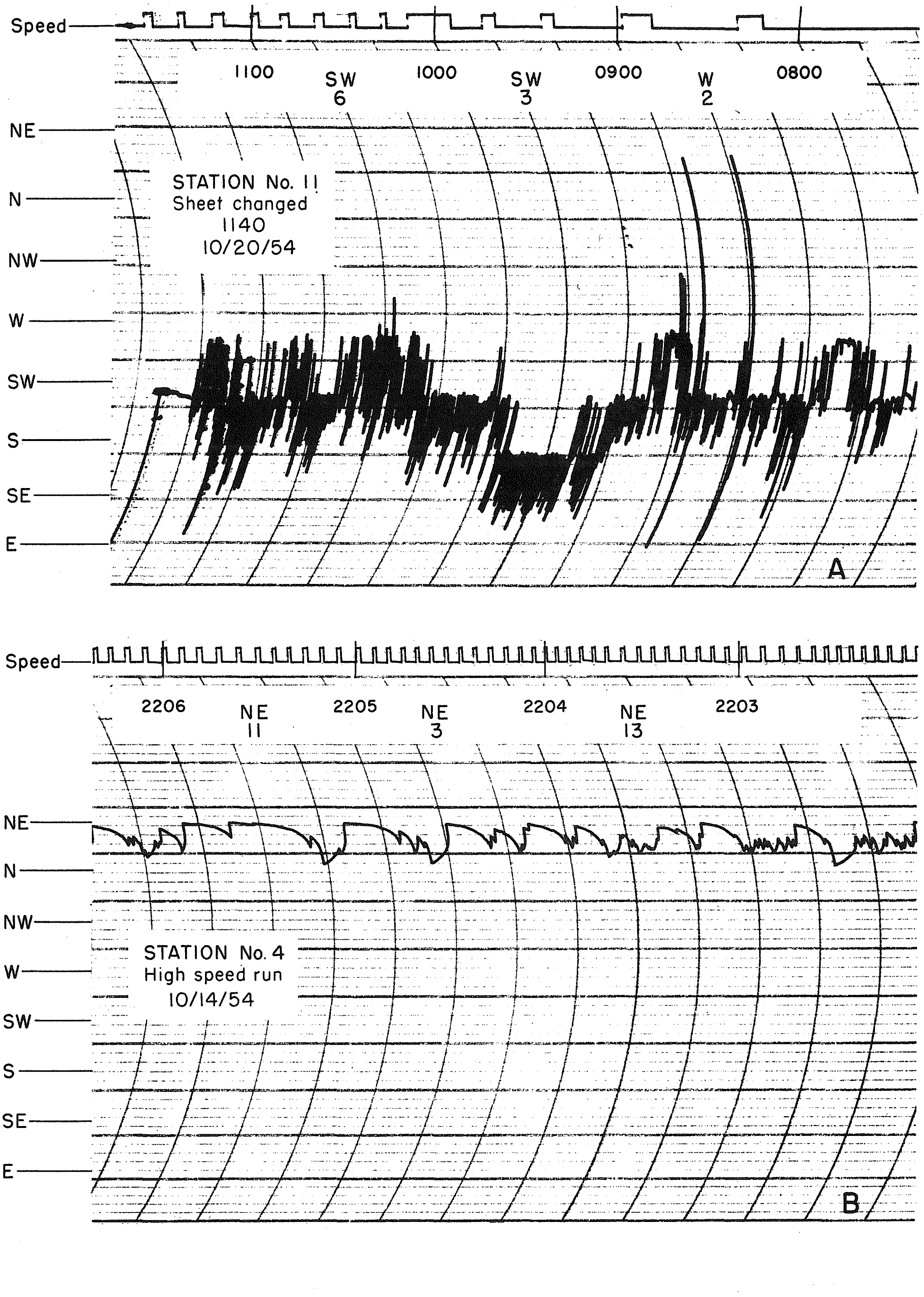


Figure 9.



STATION No. 11
Sheet changed
1140
10/20/54

STATION No. 4
High speed run
10/14/54

Figure 10. --Milliammeter recording of wind velocity and direction.

Chart A. Recorder operated at normal speed.
Chart B. Recorder operated at high speed.

b. High Speed Runs

Observations were taken on an accelerated basis on August 12-13, September 2-3, October 6-7, and October 14. Anemometers were set on the 1/60th mile contacts and the recorder charts were set to run at 1-1/2 inches per minute. This operation consisted of 2 to 3 hour steady runs in the morning, afternoon, evening, and after midnight. In a few instances, it was possible to maintain a continuous operation throughout the entire period. This operation produced a more detailed picture of the local short-time wind variations.

In this type operation, it was necessary to assign an observer to each recorder and two additional men to act as roving maintenance and repair men. A central station was set up to give out master time signals and as a central radio headquarters. The individual observers made time checks at regular intervals on the recorder traces, wound the recorder clocks at regular intervals, kept a constant check on the operation of the pens, ink supply, paper feed and supply, and changed recorder paper when necessary. Each such observation resulted in the accumulation of 75-90 feet of recorder chart records at each station.

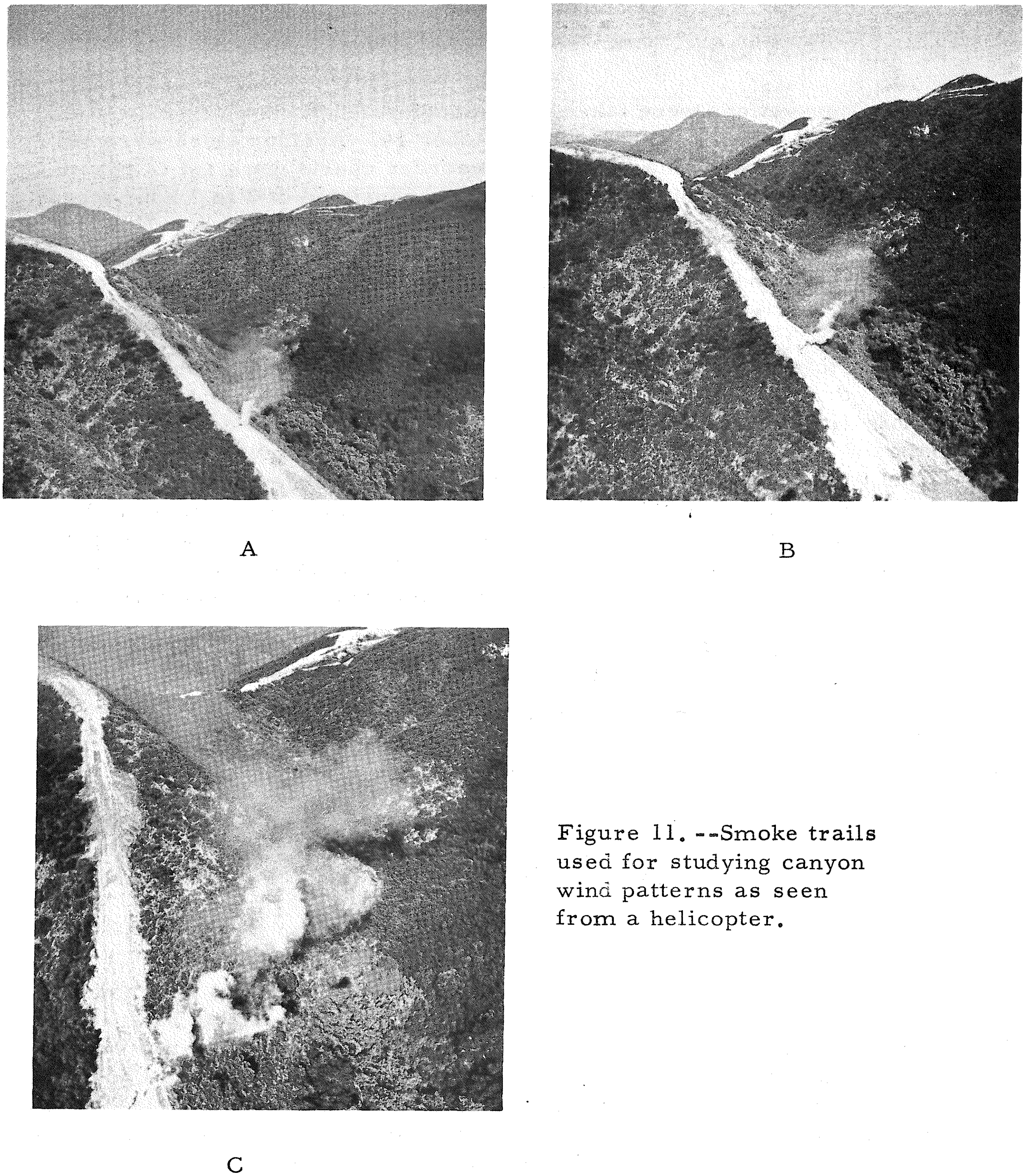
c. Smoke trails

Another technique for studying local wind patterns was the use of smoke trails. On one occasion, October 6th, four smoke bombs that produced continuous smoke for six minutes were set off at Stations Nos. 7, 8, 9, and 12. As the smoke spread from these bombs, a series of photographs were taken from a high point near Station No. 12 and from a helicopter flying overhead. Three of these photographs (Figures 11a, b, and c,) show the variability and turbulence of the wind patterns.

d. Upper air data

In order to correlate the local surface wind patterns with upper level airflow and atmospheric stability, it was necessary to have an accurate and detailed record of wind, temperature, and relative humidity profiles at the scene of operations. An Air Force Mobile Upper Air Unit was assigned to Camp Pendleton from July 20 to October 15. Rawinsondes were taken twice daily up to the 400 millibar level at 0300Z and 1500Z, (Figure 12). Additional soundings were taken on request.

Upper air data were plotted on the usual pseudo-adiabatic diagrams and wind directions and speeds at the surface and at the 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, and 14 thousand foot levels were tabulated. The height, temperature, wind direction, and wind speed were tabulated for the standard 1000, 850, 700, 500, and 400 millibar surfaces in addition to pertinent data on the inversion near the surface. This inversion was an important factor in the local weather and was present nearly every



A

B

C

Figure 11.--Smoke trails used for studying canyon wind patterns as seen from a helicopter.

day during the season. Also, soundings from nearby San Diego, Long Beach, and Riverside were plotted daily for comparative purposes.

V. DATA AND DATA PROCESSING

Each wind speed and direction recorder trace was read for the average wind speed and prevailing wind direction over a given time

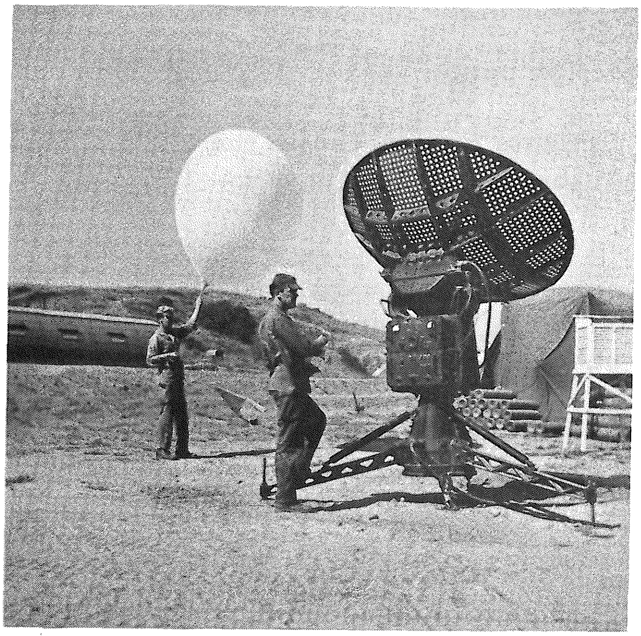


Figure 12.--Air Force mobile rawinsonde unit.

interval. Normally, these speeds and directions were read and marked on the recorder trace for every hour. For the high speed runs, the speeds and directions were read and marked on the recorder trace for every minute.

An example of the multiple pen recorder trace is shown in Figure 9. The average wind speed was determined by counting the number of 1 mile contacts in every 1 hour interval. For the high speed runs, the average wind speed was determined by the number of 1/60th mile contacts in every 1 minute interval. In the case of the Beckman Whitley recorder, the average wind speed was determined by taking a visual average of the readings on the trace for the given time interval.

Determination of the prevailing wind direction was more difficult since considerable judgment was necessary in evaluation of these records. The following rules proved useful in evaluation.

a. Traces from Stations with only 4 direction pens.

1. If an insufficient number of contacts were registered in the given time interval, the direction was listed as missing.

2. With a sufficient number of contacts in the given time interval, the direction with the most contacts was used. However, if an adjacent direction showed more than half as many contacts as the main direction, the combined direction was used.

3. With a sufficient number of contacts registered nearly equally between two non-adjacent directions, the intermediate direction was used. If the contacts were nearly equally divided between three directions, the intermediate direction was used.

b. Traces from Stations with 8 direction pens.

1. With a sufficient number of contacts registered in the given time interval, the direction with the most contacts was used.

2. With a sufficient number of contacts equally divided between two adjacent directions, the number of stray contacts on either side was checked to determine which of the two directions to use.

3. With a sufficient number of contacts registered nearly equally between three adjacent directions, the intermediate direction was used.

Determination of the prevailing direction was considerably more difficult in the case of the traces from the milliammeter recorders. Examples of this type trace are shown in Figure 10. If the contacts on the wind vane mechanism were in perfect working order, the trace would register in 8 possible positions. The prevailing wind direction had to be determined by a careful subjective evaluation of these traces. The interpretation of these traces was made more difficult by faulty contacts in the wind vane mechanisms. When the wind vane turned to a faulty contact, the trace would show a sharp discontinuity from the previous wind direction back to a zero reading.

Examples of the Beckman Whitley direction and speed traces taken during the high speed run on August 12-13th are shown in Figure 13. The extreme fluctuations in both wind speed and direction can be seen in these traces. These traces also show the variation in the magnitude of the fluctuations during different periods of the day. The greatest variability occurred during early afternoon, the time of the greatest atmospheric instability. The least fluctuations occurred during late evening after the low level inversion was well developed.

After the recorder traces were carefully read and marked, the average wind speeds and prevailing wind directions for each hour were tabulated for each station. A sample tabulation sheet is shown in Figure 14. In the case of high speed runs, average wind speeds and prevailing wind directions were tabulated for each minute at each station. Similar tabulation sheets were made of the hourly temperatures and relative humidities at each station.

VI. AVAILABLE DATA

Most of the data collected during the wind survey has been tabulated and microfilmed. While certain studies and analyses will be made by the cooperating agencies, it is hoped that other agencies interested

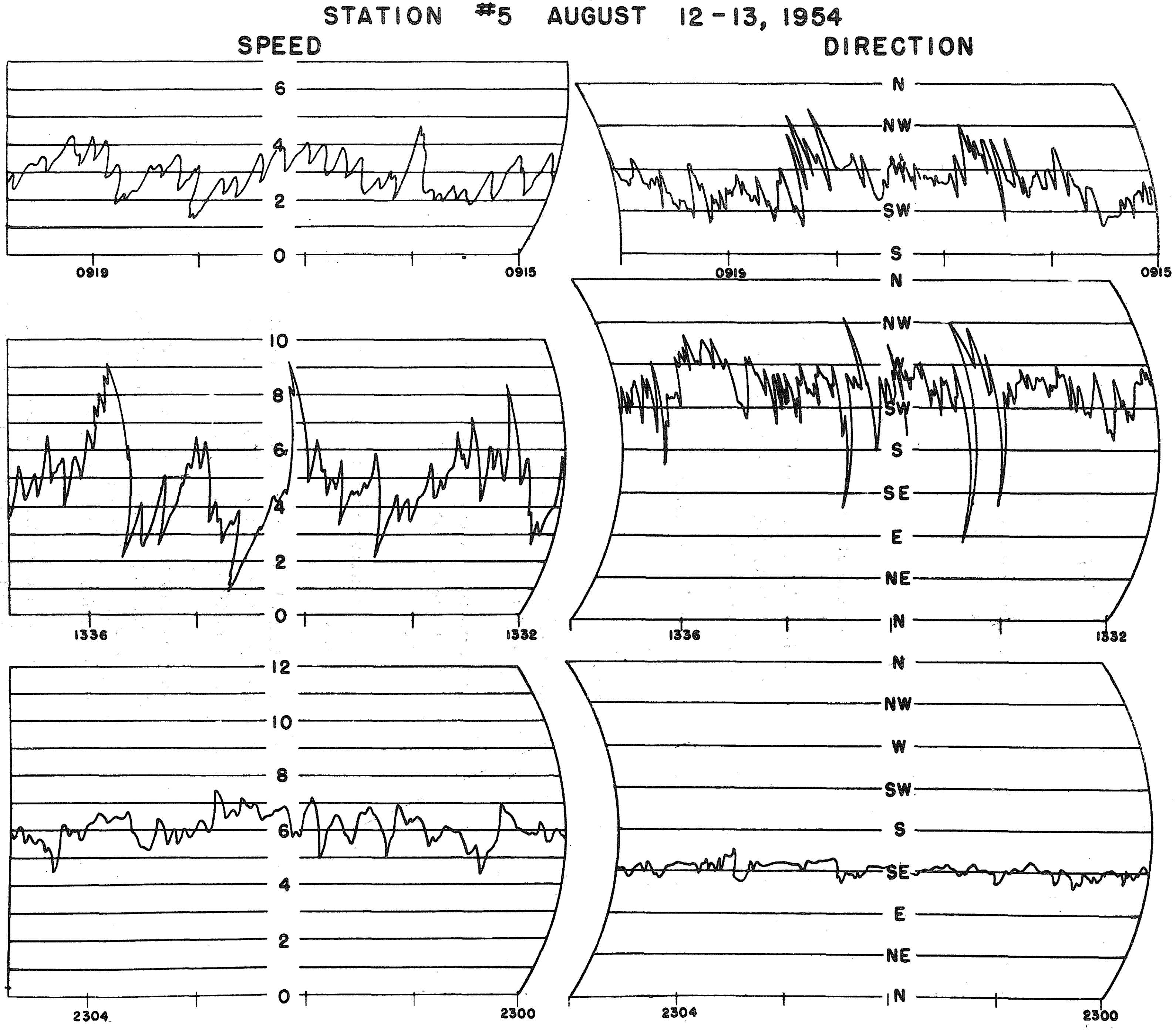


Figure 13. --Beckman Whitley wind Speed and Direction Recorder Traces.

in wind flow problems will avail themselves of these records for other studies and analyses.

A list of available data is shown below. Material which has been microfilmed and of which copies can be made, is marked with an asterisk.

a. Original data.

1. Wind recorder traces for the individual stations.

2. Wind recorder traces for the high speed runs on August 12-13, September 2-3, October 6-7, and October 14 for the individual stations.

3. Hygrothermograph traces for Stations #1, 2, 5, 11, 15, 16, 17, and 18.

b. Tabulated or recorded data.

*1. Hourly average wind speeds and prevailing wind directions for each station.

*2. Average wind speeds and prevailing wind directions for each minute at the individual stations for the high speed runs.

*3. Hourly temperature and relative humidity values at the individual stations.

4. Pseudo-adiabatic plotted charts for Camp Pendleton 7/22 - 10/6, San Diego 7/18 - 10/6, Riverside 8/14 - 10/3, and Long Beach 7/20 - 10/6.

5. Copies of transmitted teletype data for the upper level wind and radiosonde reports from Riverside, San Diego, and Long Beach. Copies of the coded upper level wind reports for Camp Pendleton.

*6. Tabulated wind speeds and directions at the 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, and 14 thousand foot levels at Camp Pendleton.

*7. Tabulated values of the heights, temperatures, wind directions and speeds at the standard 1000, 850, 700, WB Form 1078D (72)

UNITED STATES DEPARTMENT OF COMMERCE, WEATHER BUREAU

DATA SHEET; HOURLY RECORDS

Station # 1 Margarita Lookout

Data WIND SURVEY 1954

Date SEPT.	Date	A. M. 1	2	3	4	5	6	7	8	9	10	11	Noon	P. M. 1	2	3	4	5	6	7	8	9	10	11	Mid't	Sum	Mean	Date
16	1	E	E	E	SE	S	S	S	SE	NE	NE	W	W	W	W	W	W	W	W	W	SW	SW	W	NE	NE			1
16	2	9	7	8	9	8	8	3	3	6	2	2	4	6	9	8	9	8	5	3	6	5	4	3	3			2
17	3	E	SW	W	NW	NW	NW	NW	NW	SE	SW	W	W	W	W	W	W	W	W	W	W	W	W	W	W			3
17	4	3	1	4	4	5	5	4	4	1	1	2	3	7	8	8	7	9	8	8	9	9	4	2	3			4
18	5	W	W	W	W																							5
18	6	3	4	3	5	8	5	4	2	2	1	2	6	9	11	10	12	13	11	10	11	12	10	2	3			6
19	7																											7
19	8	5	6	5	6	6	3	0	3	6	2	4	6	9	10	11	11	9	10	7	3	2	2	2	3			8
20	9																											9
20	10	4	2	3	5	7	7	6	3	4	2	2	5	7	6	5	9	9	7	5	2	1	5	9	7			10
21	11												W	W	W	W	W	W	W	W	NW	N	NW	NW	W			11
21	12	1	5	6	3	4	2	1	1	2	1	3	5	10	11	12	11	12	11	13	11	8	10	8	8			12
22	13	W	W	NW	NW	NW	NW	W	W	W	SW	SW	W	W	W	W	W	W	W	W	SW	SW	SW	SW	S			13
22	14	8	11	11	10	8	9	7	9	8	7	8	7	9	10	10	10	9	8	8	9	9	8	5	3			14
23	15	S	S	SE	SE	SE	SE	SE	SE	NE	NE	NE	SE	SE	W	W	W	W	SW	S	S	SE	NE	NE	NE			15
23	16	3	6	12	11	11	12	12	12	10	10	12	10	8	4	7	4	5	2	2	3	8	10	11	10			16
24	17	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	W	W	W	W	W	NW	NW	N	SE	SE	E			17
24	18	9	9	9	9	12	13	15	13	12	8	9	8	9	6	9	11	10	9	12	9	8	6	9	10			18
25	19	E	E	E	NE	NE	SE	SE	SE	SE	NE	NE	NE	W	W	W	W	W	W	W	NW	NW	NE	E	SW			19
25	20	9	9	7	8	10	9	9	8	9	8	6	4	9	12	15	15	16	13	12	13	12	8	6	3			20
26	21	W	NW	NW	NW	NW	NW	W	NE	NE	W	W	W	W	W	W	W	W	W	W	W	NW	NW	NW	NW			21
26	22	5	6	6	7	7	3	1	2	1	2	6	10	10	13	14	16	15	14	12	13	10	10	10	7			22
27	23	NW	W	W	W	W	W	W	W	SW	W	W	W	W	W	W	W	W	N	W	W	W	W	SW	SW			23
27	24	7	8	7	8	10	10	9	7	2	6	6	9	13	12	15	16	14	12	12	10	9	6	4	2			24
28	25	SW	SW	S	SW	SW	SW	S	SE	SW	W	SW	W	SW	SW	W	SW	SW	SE	SE	SE	SE	S	S	SE			25
28	26	3	6	9	8	9	7	4	2	1	1	2	4	6	9	6	5	6	4	10	10	12	8	9	2			26
29	27	SE	SE	SE	SE	SE	S	S	SW	SW	S	SW	W	W	SW	SW	W	W	E	E	SE	S	SE	E	SE			27
29	28	7	8	4	7	6	5	4	4	4	4	4	5	7	8	7	8	3	2	10	10	4	7	8	5			28
30	29	SE	E	SE	SE	SE	SE	S	S	SE	E	SW	SW	W	W	NW	NW	W	W	W	W	W	S	E	NW			29
30	30	6	4	3	4	5	6	6	5	3	5	2	3	3	4	5	5	5	4	6	6	4	4	1	4			30
	31																											31
Sums																												Sums
Means																												Means

Figure 14. --Hourly average wind speeds and prevailing wind directions at Station No. 1. September 16-30.

500, and 400 millibar levels as well as data on the low level inversion at Camp Pendleton.

8. Copies of the 2030 PST surface weather maps (ozalid copies).

Conclusions and Recommendations

This study showed that the operational problems involved in comprehensive wind surveys in mountainous terrain are much greater than those met in the recording of the air movement at a single station. Smoke trail studies can replace conventional instruments for preliminary qualitative studies of wind movement such as are needed in determining the most suitable location for observation towers. However, it is extremely difficult to identify individual particles or puffs, therefore smoke trail studies are of limited value in quantitative wind movement studies. Reducing the voluminous data obtained from a wind survey with conventional recording instruments to a useable form also becomes a major problem. Before such surveys can become practical for the remote and inaccessible areas for which the information is needed, instruments designed specifically for the job must be developed.

Foremost among instrumental needs is a device for automatic reduction of recorded data without the need of manual compilation. Equally important is the development of more reliable sensing and recording instruments suitable for field use. Minimum requirements for such recording and sensing instruments are as follows:

1. Air movement sensing elements must be capable of operating continuously in all types of weather for at least 60 days without maintenance.

2. Recording units must be capable of maintaining a complete, accurate and legible record for at least 8 days without any attention.

3. Each air movement recording station must operate independently of any other station or central control.

4. Sensing and recording units must be capable of operating where electric power other than light weight batteries are not available. Power requirements must be low enough that battery replacement in remote locations accessible only by foot travel does not become a problem.

5. Weight and size of the units must be such that transportation by helicopter, pack-train or manpower is feasible.

6. Records produced by the recorder must be suitable for automatic data reduction.